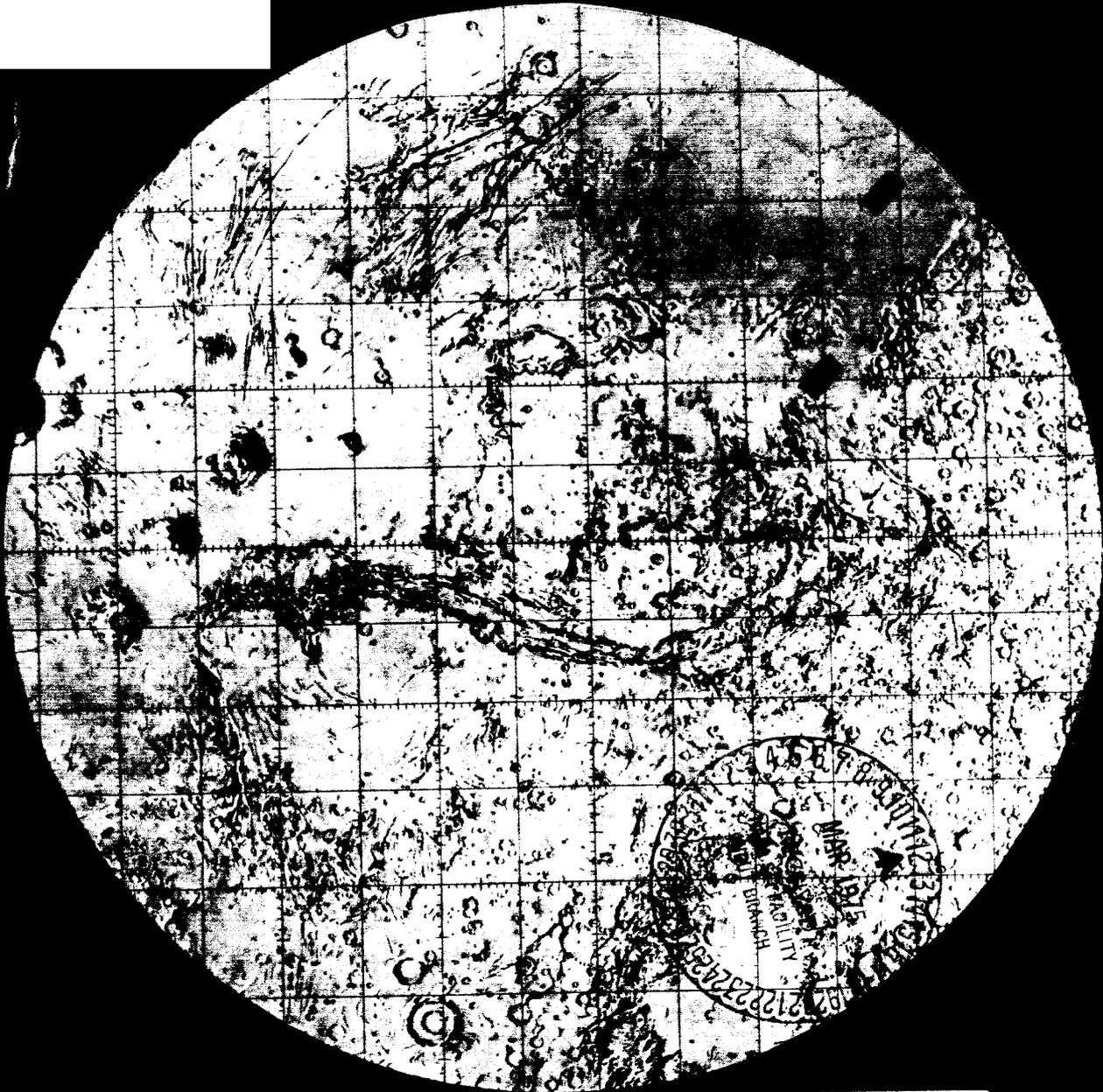


# VIKING



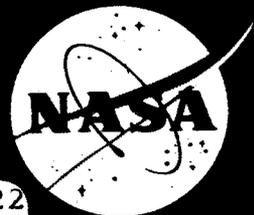
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(Editors: This fact sheet contains information on NASA's Viking program. It is suggested that it be retained in your files.)

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## VIKING

The National Aeronautics and Space Administration will launch two spacecraft to Mars in 1975 to soft-land on the surface and test for signs of life.

Called Viking, the two spacecraft will travel some 700 million kilometers (440 million miles) through space on nearly a year's journey, arriving when the planet is about 330 million km. (206 million mi.) from Earth on the other side of the Sun. Each 3,400-kilogram (7,500-pound) spacecraft will be launched from Cape Kennedy by a Titan III/Centaur rocket during a 30-day launch period between mid-August and mid-September 1975.

After confirming the site data from orbit, each of the spacecraft will separate into two parts, an orbiter and a lander. Together they will conduct scientific studies of the Martian atmosphere and surface. While the orbiter performs television, thermal and water vapor mapping, the lander will conduct analyses of the Martian soil and atmosphere.

The lander's science instruments will collect data for transmission to Earth, direct or via the orbiter, including panoramic, stereo color pictures of its immediate surroundings; molecular organic and inorganic analyses of the soil; and atmospheric, meteorological, magnetic and seismic characteristics. It will also make measurements of the atmosphere as it descends to the surface.

The entire lander system will be heat-sterilized before launch to assure that Mars will not be contaminated by Earth microorganisms. Sterilization will assure that chances of contaminating Mars are less than one in a million.

### Importance of Viking

Is Earth truly a unique life-supporting planet in the immense totality of creation? There is growing evidence to the contrary. Our Galaxy contains 100 billion stars, many of which are surrounded by families of planets, according to the best astronomical evidence. In studying these stars with telescopes, man has been able to verify that the basic chemicals of which Earth is composed are found throughout the universe. In just the last century, it has been proven that the ratio of these elements in our own solar system is consistent with the overall ratio generally observed throughout the universe.

Further, radio astronomers have detected simple organic compounds in interstellar space. Recent detection of complex organic compounds has increased our confidence that life could evolve on other worlds. But science cannot calculate the probability of encountering extraterrestrial life in this solar system and in other solar systems on the basis of this evidence. We cannot tell conclusively by laboratory studies or theoretical reasoning whether the evolution of life is vanishingly improbable or quite likely. We can only estimate the probability by looking around us for signs of extraterrestrial life. The nearest reasonable planet on which to look is Mars.

Mars is dry, cold and less favorable than the Earth for the support of life, but it is not implacably hostile. Life could exist in the harsh climate of Mars, and if it does, we will know that on planets with comfortable climates--similar to that on Earth--the chances of finding life are substantial. We will have strong reason to believe that many inhabited solar systems--perhaps billions--lie around us in the Galaxy.

Viking exploration may also settle a question of equal importance for determining the probability of life arising out of nonliving chemicals: Is it possible that Mars is lifeless today, but was once the site of a rich variety of life that disappeared later in the history of the planet?

The question turns on the abundance of water. Mars is relatively dry today, but discoveries by Mariner 9 of volcanism and riverbeds on Mars suggest that the planet could have had a substantial supply of water that at times became available in liquid form. The water could have remained long enough to permit some form of organism to evolve, only to be snuffed out later when the vital gases and water on Mars disappeared. If that happened, we may still find traces of one-time life on the surface.

Even if no signs of life, extant or extinct, are found on Mars, it is crucially important to study the nature of other planets presumed to have originated at about the same time and by the same processes as Earth. In this context, finding that Mars is without life could be nearly as important as the discovery of life forms. The study of a planet--not too dissimilar from Earth--which has evolved in the absence of life would provide us with a yardstick with which to determine, for example, how the atmosphere of Earth has been influenced by the advent of biological processes. Comparative planetology will be of great value in understanding our own Earth, and in formulating measures to protect our own environment.

These possibilities make the exploration of Mars the most important objective of planetary exploration for many decades to come.

### Previous Mars Missions

The Mariner Mars flights have supplied most of the Martian data which permit us to plan and design the Viking mission. These data include atmosphere composition, atmospheric structure, surface elevations, atmosphere and surface temperatures, topography, figure of the planet and ephemeris information.

As a result of the Mariner missions, much experience has been gained also in conducting an orbital mission, inserting a spacecraft into planetary orbit, and processing large quantities of digital data. The design of the Viking orbiter is based on the Mariner spacecraft, with many of the subsystems being nearly identical.

The Mariner flights have provided the logical steps in the exploration of Mars which had to precede Viking, just as Viking is a necessary prelude to eventual sample return by automated roving vehicles and possible manned missions to Mars.

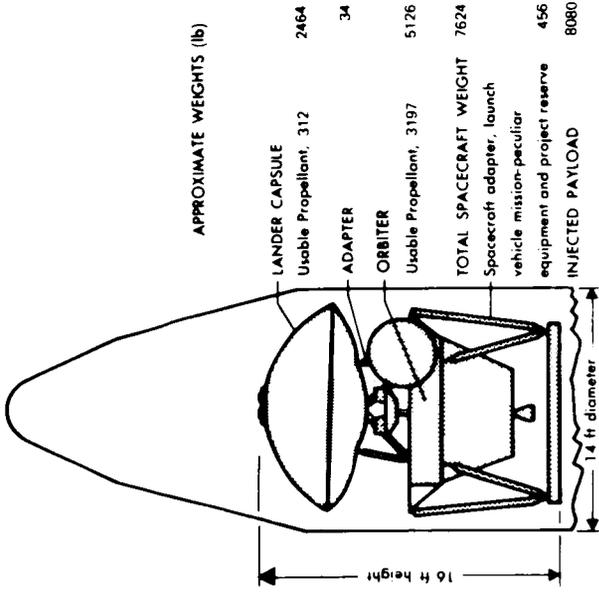
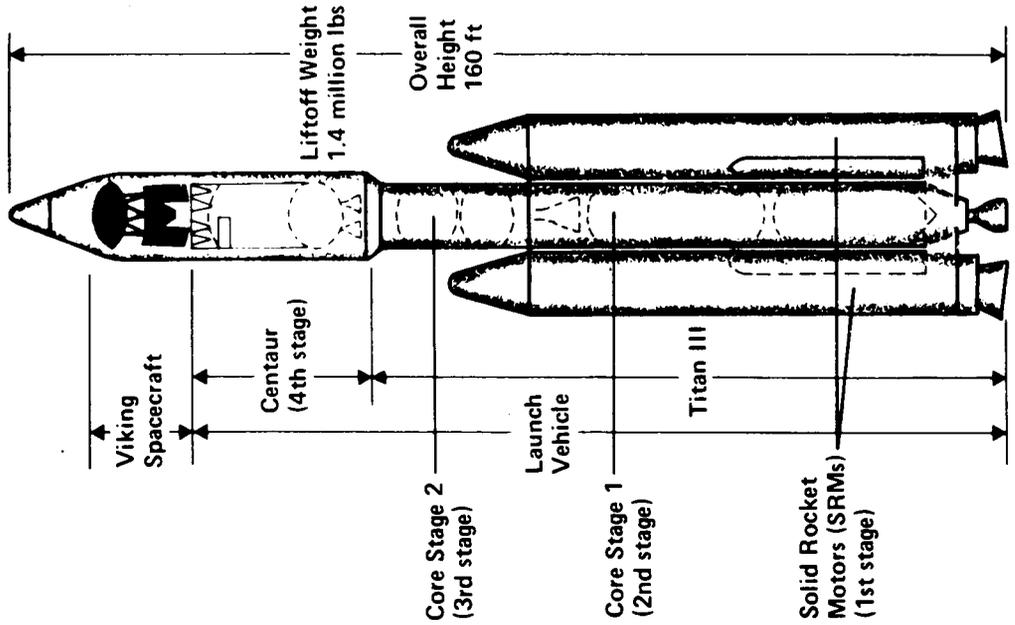
### Viking Launch

The launch period was selected to provide a minimum-energy trajectory from Earth to Mars. Opportunities for such flights occur at approximately 25-month intervals.

In separate launches spaced at least 10 days apart, two Titan/Centaur rockets will lift off from Cape Kennedy, each placing the Centaur upper stage and the Viking spacecraft into a 184-km (115-mi.) parking orbit. After coasting for 30 minutes, the Centaur will reignite to send the spacecraft on its journey to Mars.

# Viking Space Vehicle

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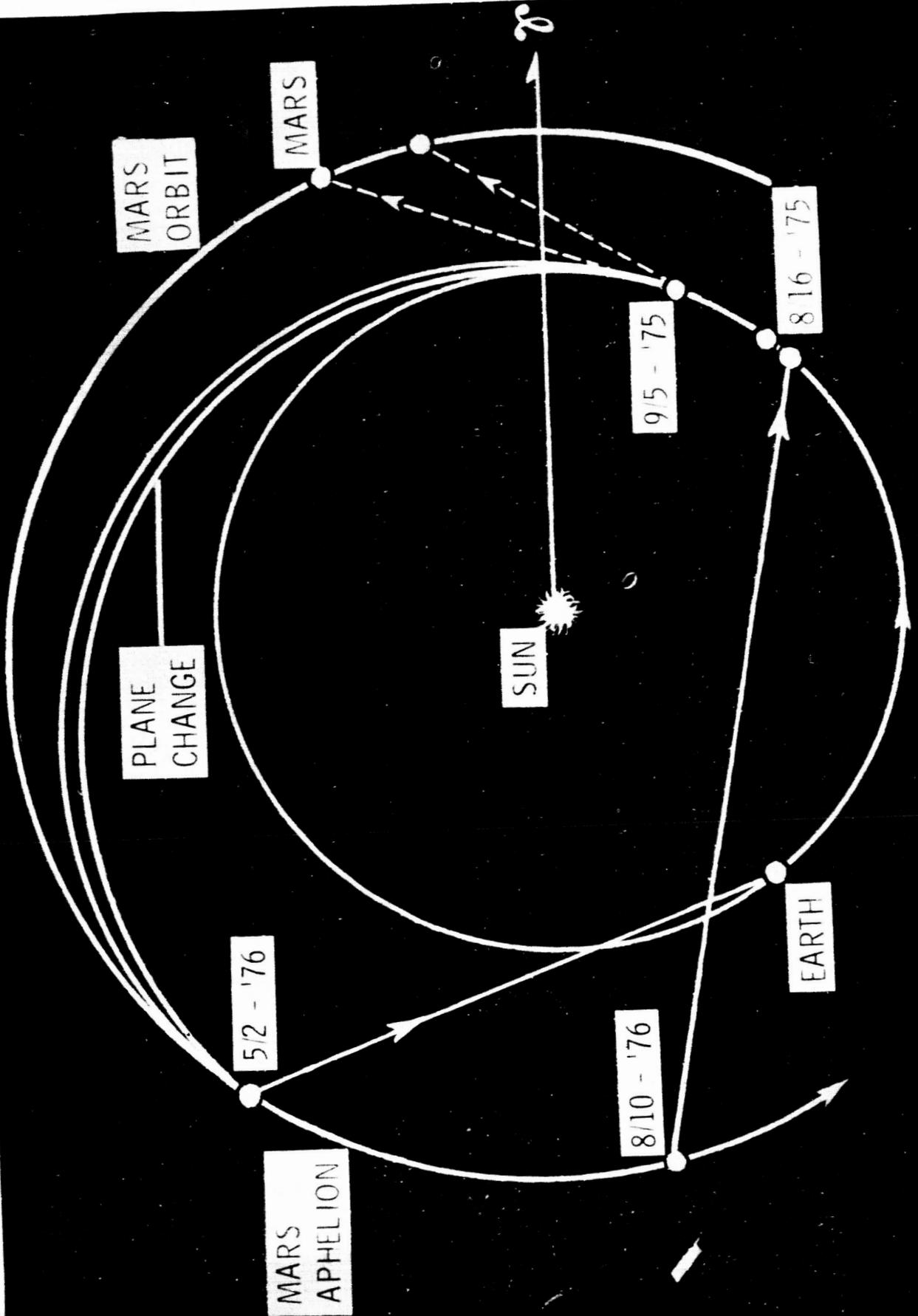


APPROXIMATE WEIGHTS (lb)

|   |                         |      |
|---|-------------------------|------|
| LANDER CAPSULE  | Usable Propellant, 312  | 2464 |
| ADAPTER   | Usable Propellant, 34   | 34   |
| ORBITER   | Usable Propellant, 3197 | 5126 |
| TOTAL SPACECRAFT WEIGHT   | 7624                    |      |
| Spacecraft adapter, launch vehicle mission-peculiar equipment and project reserve | 456                     |      |
| INJECTED PAYLOAD  | 8080                    |      |

| STAGE   | THRUST (lb) | PROPELLANTS |
|---------|-------------|-------------|
| Centaur | 30,000      | Liquid      |
| Core 2  | 100,000     | Hypergolic  |
| Core 1  | 520,000     | Hypergolic  |
| SRMs    | 2,400,000   | Solid       |

# EARTH-MARS TRAJECTORIES -1975 LAUNCH



The Titan booster is a two-stage, liquid-fueled rocket, with two additional large, solid-propellant rockets attached. It is a member of the Titan family used on NASA's manned Gemini program. The Centaur is a liquid oxygen-liquid hydrogen, high-energy upper stage used on unmanned Surveyor flights to the Moon and on Mariner flights to Mars.

At liftoff, the solid rockets provide 9.61 million newtons (2.16 million pounds) of thrust. When the solids burn out, the first stage of the Titan booster ignites, and is followed by the second-stage ignition as the first stage shuts down. The Centaur ignites on second stage shutdown to inject the spacecraft into orbit. Then after a 30-minute coast around the Earth into position for restart, the Centaur reignites to propel Viking on its Mars trajectory. Once this maneuver is completed the spacecraft separates from the Centaur, which is subsequently deflected away from the flight path to prevent its impact on the surface of Mars.

Shortly after separating from the Centaur, the orbiter portion of the combined orbiter-lander spacecraft orients and stabilizes the spacecraft by using the Sun and a very bright star in the southern sky, Canopus, for celestial reference.

### Journey Through Space

Viking may have to make several flight corrections during its journey. These corrections will be based on navigation information acquired from Earth-based tracking of the spacecraft. Thus by firing its orbit-insertion engine several times in a predetermined direction the spacecraft's trajectory will be altered to insure interception of Mars.

Power is produced by solar panels which open up after injection into orbit, spanning more than 10 meters (33 feet) tip to tip. Batteries are used when the panels are shaded from the Sun or when peak power is demanded. In turn, the batteries are charged by the solar panels. Small attitude control jets on the edges of the orbiter's four solar panels keep the spacecraft stabilized and oriented.

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# MISSION SEQUENCE



ENTRY TO LANDING  
5-10 MINUTES

The orbiter will furnish electric power to the lander until separation. The lander has a set of rechargeable batteries which will be charged during Mars surface operations by two radioisotope thermoelectric generators (RTG's) being provided by the Atomic Energy Commission (AEC). The RTG's convert heat produced by the nuclear source into electricity, making the landers independent of solar energy.

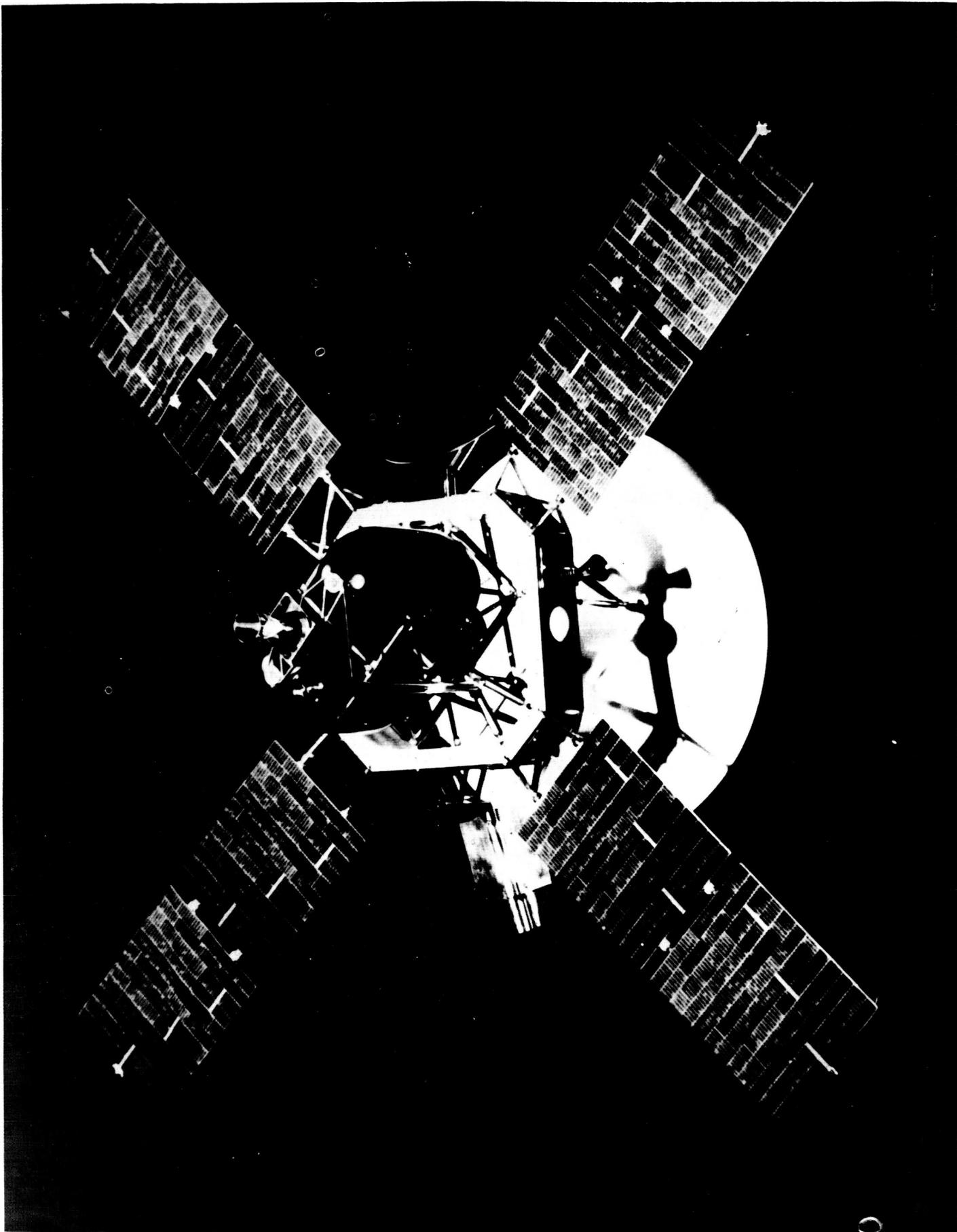
Information concerning flight performance is transmitted to Earth throughout the flight. An onboard computer controls all spacecraft operations and supplies commands for trajectory corrections in addition to controlling the orbiter's scientific equipment while in orbit. At the same time, ground controllers will be monitoring all phases of the mission via the worldwide tracking facilities.

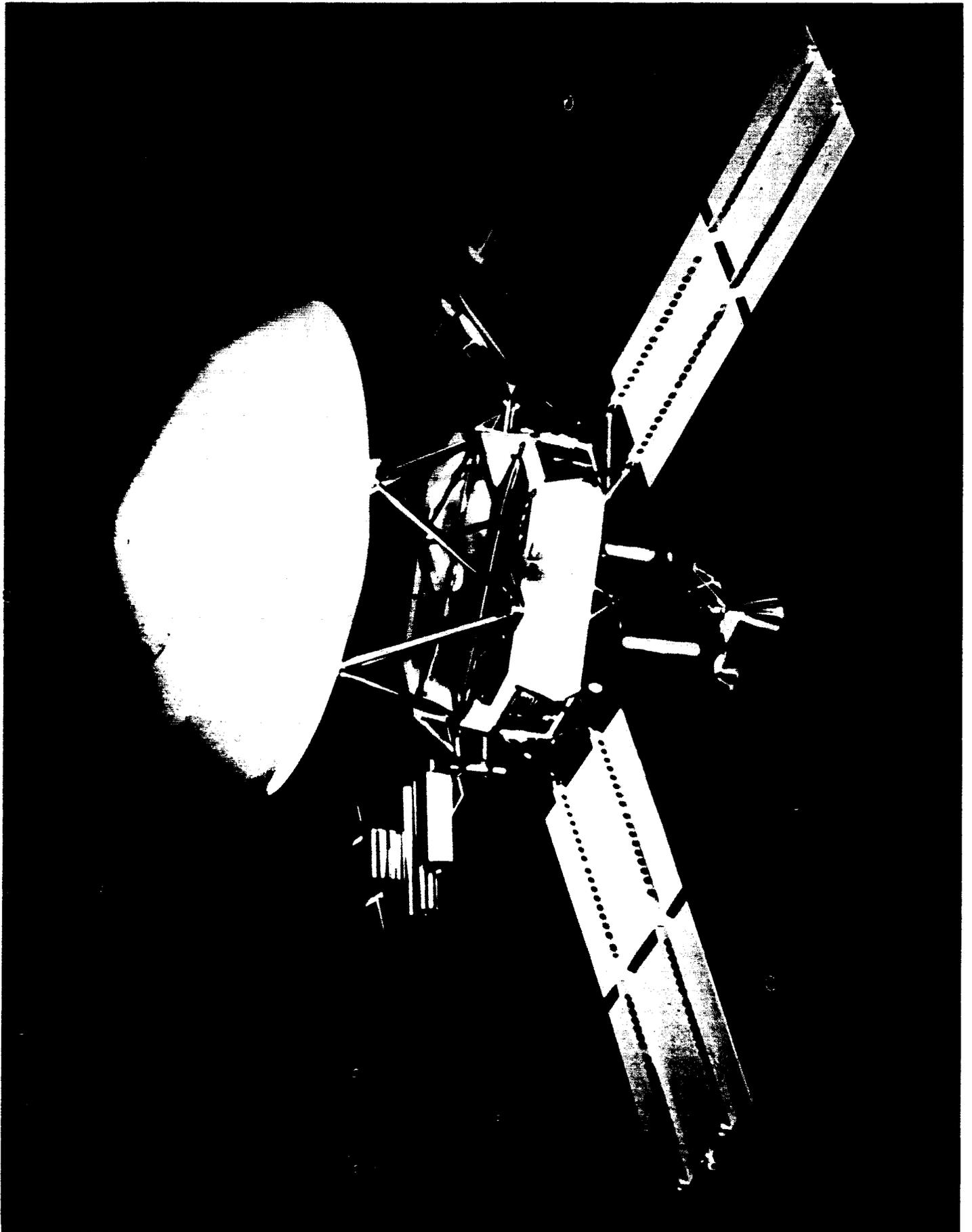
### Tracking

The Deep Space Network (DSN) supporting Viking will consist of two networks, each with three stations having 26-m (85-ft.) antennas and one network of three stations with 64-m (210-ft.) antennas. The 64-m stations will be located in California, Australia and Spain. During most of the Viking interplanetary flight, the spacecraft will be in contact with one of the stations. During orbital operations at Mars, there will be continuous tracking of the spacecraft by one of the larger DSN stations.

In addition to tracking the precise path of the spacecraft, this system processes three kinds of data: engineering telemetry, science, and commands to the spacecraft to initiate or change programmed operations.

Communication with Viking will take longer and longer as the spacecraft gets farther away from Earth. When it reaches Mars, a one-way message will take 20 minutes. This means a roundtrip minimum of 40 minutes will pass before a command from Earth can be received by the spacecraft in response to its initial transmission. For this reason, automation is essential. Operations that cannot be interrupted, such as the soft landing, will be performed automatically by an onboard preprogrammed computer.





## Injection into Mars Orbit and Landing

As the spacecraft nears the planet, it is maneuvered into the proper attitude for being placed in orbit. The engine will be fired for nearly an hour to place the combined orbiter and lander in a highly elliptical orbit of 1,500 km (930 mi.) by 33,000 km (20,500 mi.), a period of approximately 24 hours to match Mars' period of rotation.

The spacecraft will be tracked for at least 10 days after achieving orbit to obtain detailed information for a precise landing, as well as to check out preselected landing sites. Mission controllers will have as many as 50 days to further study the planet to confirm optimum landing sites.

The lander is prepared for separation after confirmation of a landing site based on observational data from Mariner 9 as well as Viking observations. An ideal landing area would be relatively low, warm, wet, safe and interesting.

## Landing

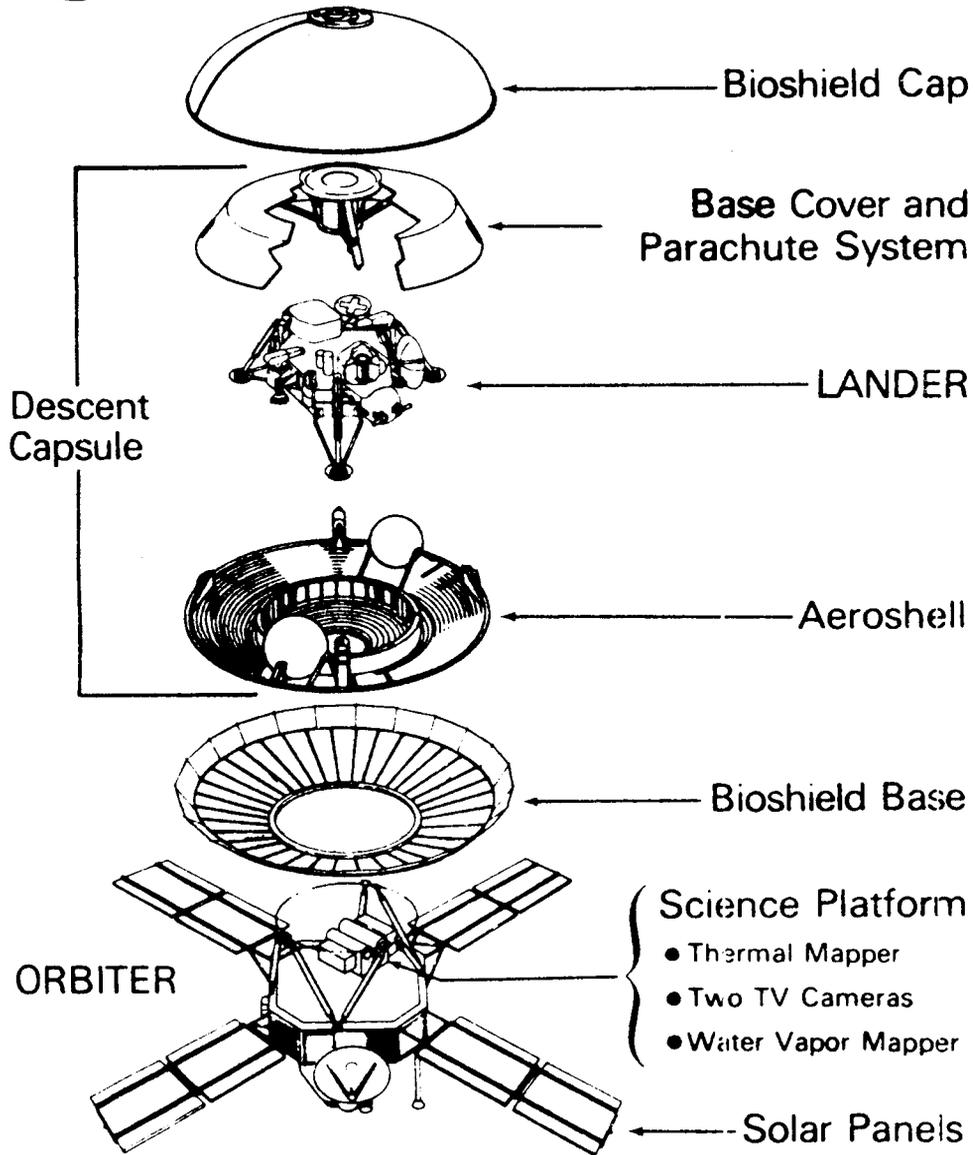
The Viking lander instruments, weighing about 91 kg (200 lbs.), are divided into two areas of investigation, those used during the atmospheric entry phase prior to landing and those used on the Martian surface. Entry data will provide information on the composition of the upper atmosphere and on the pressure, temperature and density of the lower atmosphere.

When a landing area has been determined, the lander's power is turned on, and the lander within its aeroshell separates from the orbiter. The aeroshell shields the lander against the intense heat generated as it decelerates during the high-speed entry through the thin CO<sub>2</sub> atmosphere.

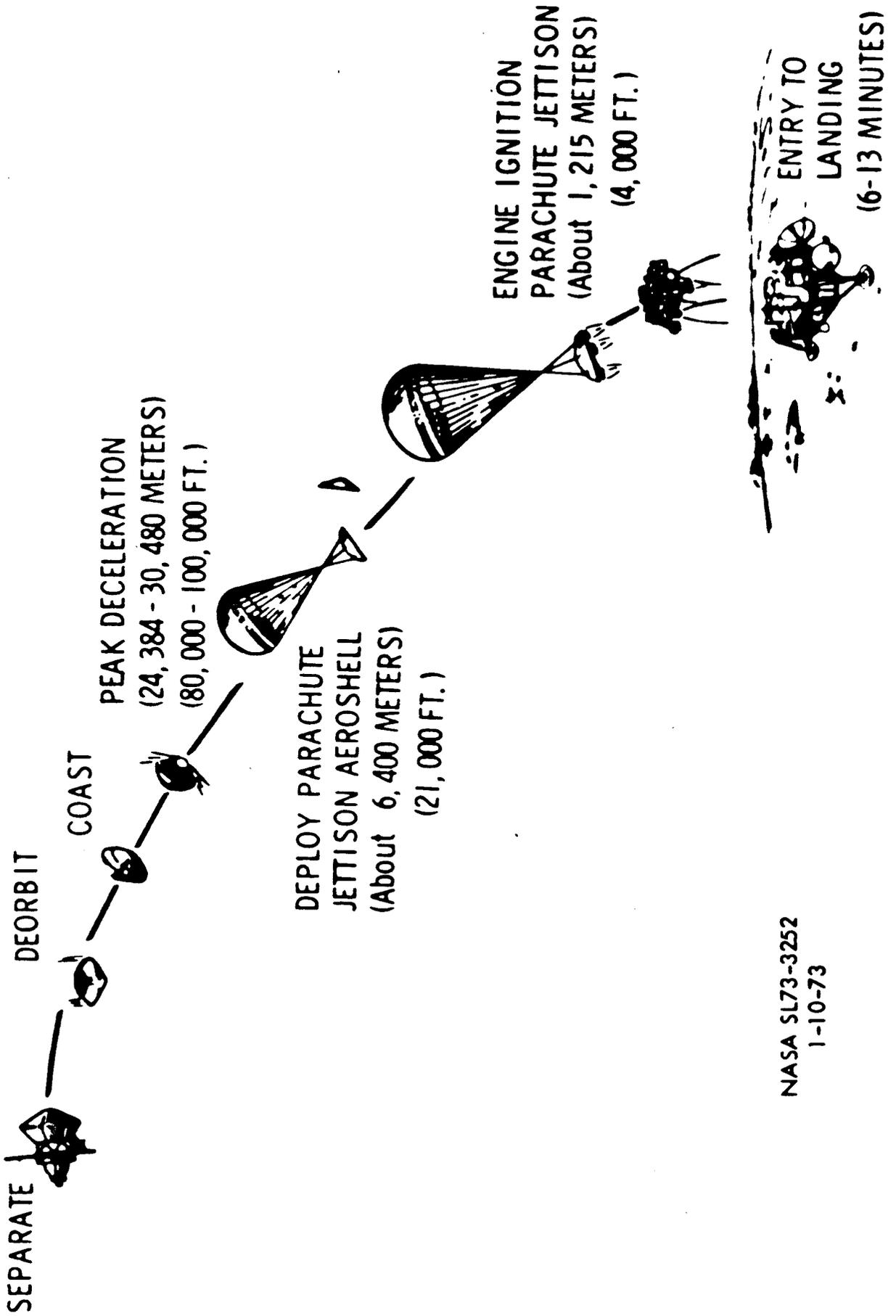
During descent and landing, the lander maintains communication with the orbiter, which serves as a relay station between Mars and Earth.



# EXPLODED VIEW OF SPACECRAFT



# LANDER DESCENT PROFILE



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A 50-foot parachute is deployed to further decelerate the lander at about 6,000 m (20,000 ft.) above the surface. Shortly thereafter, the aeroshell is jettisoned. The parachute is jettisoned about 1.6 km (one mi.) above the surface as the terminal propulsion system begins firing its three engines. This is a rocket subsystem similar to that used by the Surveyors to soft-land on the Moon.

The engines, firing 5 to 10 minutes, slow the lander for a soft landing and shut down just as the foot pads touch the surface.

As soon as the lander is on the surface, all systems except those necessary for science operations are shut down to conserve power. The lander's computer immediately determines its attitude on the surface to provide information necessary for aligning the S-band transmitting/receiving antenna with Earth.

Scientific data and monitoring information are immediately relayed to Earth via the orbiter. At the same time, the two 35-watt (electric) nuclear-fueled generators are recharging the lander's batteries so operations can be continued for at least 90 days.

The lander instruments consist of a gas chromatograph/mass spectrometer for detecting and identifying organic molecules, the building blocks of life, in the soil; a biology instrument capable of performing three different life detection experiments; three meteorology sensors; a seismometer; an X-ray fluorescence spectrometer for inorganic chemical analysis of surface material; two facsimile cameras; and magnets plus a collector head on a boom to collect soil samples and measure surface properties.

The cameras will give the 66 principal scientists participating in Viking a vastly improved view, in color and stereo, of the Martian topography and surface structure. Of even greater interest to life scientists will be the results obtained from the organic and inorganic analyses of the Martian soil, and from the three life-detection experiments.

Lander instruments will also determine the temporal variations of atmospheric temperature and pressure, and wind velocity and direction; seismological characteristics of the planet; the atmospheric composition and its variation; and the magnetic and physical nature of the surface.

### Orbiter

While experiments are proceeding on the surface, the Viking orbiters will be circling overhead, observing the landing site, so that local measurements made by the landers may be correlated with overall surface effects. The orbiters will look for conditions such as buildup of dust storms, cloud formation, variations in temperature and humidity, and the passage of the seasonal wave of darkening.

The Viking orbiters each carry about 69 kg (152 lbs.) of instruments, consisting of two high-resolution television cameras, an infrared spectrometer and an infrared radiometer. These instruments will be employed to survey landing sites both before and after lander deployment in order to provide data on surface temperature, atmospheric water concentration, the presence of clouds and dust storms and their movement, the topography and color of the terrain, and other information to describe the broader aspects of the landing site and its relationship to the overall planet characteristics. This information will then be integrated with the lander data for a better understanding of what is happening on the surface.

## VIKING INVESTIGATIONS

### The Search for Life

If life exists on Mars, it is probably in the form of microorganisms. To search for evidence of their existence in the surface samples, three different investigations will be performed. The biology instrument will examine three different soil samples, which will also be analyzed by the molecular analysis instrument for organic content and by the X-ray fluorescence spectrometer for chemical composition.

Photosynthetic Analysis - Photosynthesis is the process by which organic compounds, such as carbohydrates, are formed by combining basic compounds like carbon dioxide, water and salts, using the Sun as a source of energy. It is a basic life-sustaining process; plant life on Earth consumes carbon dioxide during photosynthesis.

In the Viking experiment, a soil sample is inoculated with carbon dioxide gas that has been labeled with a radioactive tracer. The soil and gas are then allowed to incubate in simulated Martian sunlight for a period of time. Later, all remaining gas is flushed out of the chamber and the sample is heated to 600° C (about 1100° F). The heating will liberate any of the labeled carbon dioxide incorporated into organic molecules in a photosynthesis process, and the liberated gas can then be measured. A substantial quantity of labeled gas would indicate that a photosynthetic process had taken place, which would be strong evidence of the presence of living plant-like organisms.

Metabolic Analysis - It is possible that the organisms sustain life by obtaining nourishment from organic materials rather than through photosynthesis. Therefore, an analysis very similar to the photosynthesis reaction analysis has been planned, which will "feed" organic compounds containing radioactively labeled carbon to the soil sample--sugar, as an example. If organisms are in the sample, and they can consume the food offered to them, they will discard--as waste--radioactive carbon gases that can be measured. A sharp rise in the production of such metabolic gases would be strong evidence that life is present.

Respiration - As metabolism takes place, the composition of the gaseous environment is in a state of continuous change. For this analysis, which is closely related to the metabolic conversion analysis already described, the sample is wet with a growth medium.

A sample of the Martian atmosphere is pumped into the chamber headspace above the sample and monitored. Changes in the composition of the gases will again be evidence of the existence of life as a result of cellular respiration.

In the event of positive results from one or more of these experiments, a control sample will be prepared to further verify the evidence. The control sample is heat-sterilized to ensure that all living organisms are destroyed before analysis is made. Then, if the result is changed, scientists can be relatively certain that the original result was due to the existence of living organisms.

### Molecular Analysis

This investigation will perform a chemical analysis of the Martian atmosphere and soil. The chemistry is important in all scientific aspects of understanding the planet, but particularly so for biology. All known life is organic (composed of substances such as sugars, fats and proteins).

The composition of the atmosphere is important in understanding the overall chemistry of the planet and in attempting to trace the history of its information.

Both the atmospheric and soil analysis consist of detecting and identifying specific molecules by using a device called a gas chromatograph-mass spectrometer. For the atmospheric analysis, the method is simply to "sniff" the Martian atmosphere with the mass spectrometer. The device is sensitive to one part per 10 million, and will detect any volatile chemical whose molecular weight is less than two hundred. Seasonal variation in atmospheric composition may strongly influence or be evidence of biological activity, as might unusual isotope ratios or compounds in unstable equilibrium with the environment.

The soil analysis is more complex. The instrument contains several tiny ovens; each can receive a soil sample from the soil processor. The ovens are heated to 500° C (about 900° F). During heating the organic compounds are vaporized and analyzed. If a living system has not evolved on Mars the organic analysis may help explain and provide knowledge of pre-biological organic chemical evolution. A high yield of organic material would support a positive active biology result or, in the absence of a positive active biology finding, suggest the possible presence of organisms which did not respond to the conditions in the biology instrument; a high yield of organic material in the absence of a positive result for active biology could be indicative of earlier biological activity.

### Inorganic Chemistry

This investigation will perform an elemental analysis of the Martian soil. The elemental composition will identify existing rock types on the planet and is important in determining the degree of differentiation that has occurred on the planet. The inorganic composition and character of the surface are important to the biologists, as well as to geochemists and planetologists.

The analysis will be performed by an X-ray fluorescence spectrometer. The instrument consists of two radioisotope X-ray sources which bombard the surface material, inducing X-ray fluorescence, and four thin-window proportional counters which detect and differentiate the spectrum of the induced fluorescence. The instrument is capable of quantitative analysis for most major, minor, and some trace elements with a sensitivity range of 0.02 per cent to 2.0 per cent, depending upon the element.

The sample to be analyzed would be obtained by the surface sampler and delivered to the instrument by the soil processor and be a part of the same sample examined for organic content and living organisms.

### Imaging System

Viking will extend our knowledge of Mars by examining unique sites at a higher resolution than previously obtained. The Viking visual imaging system on the orbiter will obtain pictures with a resolution of about 39 m (130 ft.) per television line at an orbiter altitude of 1,500 km (930 mi.), permitting one to distinguish objects about the size of a football stadium.

The orbiter system consists of two identical cameras, each composed of a telescope, filters, TV tube and appropriate electronics.

Prior to initiation of the landing sequence, the orbiter camera will aid in confirmation of the preselected landing sites or, if necessary, in the identification of suitable alternatives. After landing, the lander observations will be available to verify and extend the interpretation of orbiter camera pictures for a more detailed

understanding of the physical and chemical character of the surface in areas other than the landing sites. Valuable data are also expected relative to variable features such as clouds, dust storms and seasonal albedo changes.

Picture 1 is taken by Camera 1 and stored in the tape recorders. Picture 2 is then taken by Camera 2 and, while it is being put in the tape recorder, Camera 1 is prepared for taking Picture 3 by erasing the previous picture from the TV tube. This process is repeated until the required pictures are acquired.

### Lander Camera

On the Viking lander, two facsimile cameras will substitute for man's eyes. They can be directed to look down at the ground nearby, or perform a 360-degree panoramic scan of the entire landscape.

The cameras will take pictures in high quality black-and-white and color, and in the near infrared region of the spectrum. Pictures taken by the two cameras can also be combined to yield stereoscopic views of the areas.

The pictures will convey a great deal of information about the geological character of the surface of Mars, and could identify any higher form of life that may exist. Clouds and dust storms may be seen. The cameras will help in selecting the places where the surface sampler is to dig for soil specimens to be analyzed by the other instruments. Pictures of the digging itself will provide information on the physical properties of the soil.

The facsimile camera operates by using a small mirror which scans a vertical line and projects the image light intensity slowly onto a small detector. After that line is scanned, the camera is turned 0.1 degrees and another vertical line is scanned. This process is repeated many times to build up an image from the many scan lines. The detector is a small photocell that converts the light in the picture image to an electronic signal which is then transmitted to Earth. The picture is obtained by reversing the process, converting the electronic signal to a light which is scanned over a film to prepare a negative for making the photograph.

### Entry Science

As the lander enters the atmosphere and descends to the Martian surface, there will be an opportunity to learn about the structure and chemical composition of the atmosphere.

Atmospheric chemical composition will be measured at short intervals during the lander aeroshell's descent to identify changes in composition at different altitudes. This investigation will show the proportions of gases such as carbon dioxide, nitrogen, oxygen, argon and of particles such as ions and electrons. Pressure, temperature and density variations with altitude will be measured during the descent at low altitude to determine the atmosphere's vertical structure.

These investigations are divided into two phases: the aeroshell phase (entry), and the parachute phase (descent). During the aeroshell phase, atmospheric composition, temperature, pressure and density will be observed. To accomplish this phase of the study, temperature and pressure sensors, a magnetic sector mass spectograph and a retarding potential analyzer are mounted on the aeroshell. After aeroshell separation, temperature and pressure sensors mounted on the lander itself will continue the measurements to the Mars surface and provide supporting data on the surface for the duration of the mission.

The mass spectrometer measures the relative amounts of the gases making up the atmosphere, as well as identifying the molecules. The retarding potential analyzer measures both the concentration and the energies of upper atmosphere ions and electrons. Atmospheric density is derived from the pressure and composition data together with the aerodynamic drag on the spacecraft as indicated by the accelerometers.

### Water Detection

The Mars atmospheric water detector on the Viking orbiter can detect very small amounts of water vapor with a high resolution.

The water detector is an infrared spectrometer which operates on the following principle: If water vapor is in the atmosphere, it will absorb a particular part of the infrared light that is produced by the Sun in much the same manner that ozone in our atmosphere absorbs the ultraviolet light, or a yellow filter absorbs all colors except yellow. The infrared spectrometer can determine that the particular part of the infrared light has been absorbed and how much has been absorbed. This in turn tells the scientists that there is water vapor in the atmosphere and how much.

### Thermal Mapping

The intensity of the infrared energy that is radiated by the Mars surface is an indicator of the surface temperature. The infrared thermal mapper on the Viking orbiter can measure the radiated energy and therefore provide scientists with the data necessary to determine the surface temperature of Mars. Similar measurements were made by Mariners 6, 7 and 9, however, these measurements cover narrow strips of the surface. The Viking thermal mapper will cover large continuous areas at a better resolution than previously obtained. Thermal mapping data will contribute significantly to the selection of landing sites and provide a temperature map of much of the planet at various times, both day and night. In addition, scientists may be able to locate features such as volcanoes, using the temperature information provided.

### Radio Science

The radio communications system can be used as a scientific instrument by measuring the alterations of the radio signals caused by the planet and its atmosphere.

As the radio signal passes through the atmosphere, the signal is changed and observation of the type of change will help characterize the atmosphere.

The radio system--including the radar--will be used for measuring the gravitational field of Mars, determining the axis of rotation, measuring the surface properties, and performing certain relativity experiments. It will also be used to determine the location of the lander on the ground

A special radio link, the X-band, is very useful for studying charged particles, the ions and electrons. This is particularly so for measurements of the ionosphere of Mars. It also will be used for solar corona experiments when Mars and the Earth are lined up with the Sun.

The radio data will be received by the three large 64-m (210-ft.) antennas of the Deep Space Network; the large antenna at Britain's Jodrell Bank will also receive signals for an experiment in long-based interferometry.

#### Weather Station on Mars

Weather has been an important factor in shaping the thermal history and geological character of Mars. The meteorological conditions also affect any life that may exist on the planet. Like Earth's, the dynamic weather conditions on Mars undergo cyclic changes both daily and seasonally.

Periodic measurements will be made of the atmospheric temperature, pressure, and the wind speed and direction for the duration of the mission.

#### Physical and Seismic Characteristics

Geological measurements will be made of the physical and magnetic properties of the surface and of the internal seismic activity. Scientists do not know the level of motion within Mars, but will record for periods long enough to establish whether it is a very active planet or not. Such information could shed light on the early history of the planet.

A sensitive miniaturized seismometer is mounted on the lander. The seismic background and the larger events, such as Mars quakes or meteoroid impacts, are measured with a three-axis device capable of detecting ground motion transmitted through the lander legs. The instrument uses a rapid data mode during special seismic events to obtain much more data during those periods.

The magnetic properties of the planet are measured by small but powerful magnets mounted on the lander soil sampler. These magnets will come into contact with the surface during soil sample acquisition, then will be maneuvered in sight of the Viking cameras to be viewed with and without a 4-X magnifying mirror. Pictures of clinging particles will be evidence of magnetic material in the soil.

The cameras will also photograph the footprints of the lander and the trough made by the sampler, enabling scientists to study the cohesive properties of the soil, its porosity, hardness and particle size. Such observations will help them to deduce information about the physical properties of the planet's surface. Observations of the trough over several weeks time will also give an indication of particle transport and the erosion potential of Martian winds.

#### COMMUNICATIONS

Both the orbiter and the lander are capable of communicating with Earth. The lander system is limited by power and thermal constraints to transmission periods of several hours daily. The orbiter system can transmit at high data rates continuously and can also be used as a relay station for data transmitted from the lander. Both the lander and the orbiter have data storage systems which collect data at rates higher than the transmission rates to Earth, and both can be commanded over these communicative systems from the Earth.

Three kinds of communications systems will be used. S-band microwave links are used to transmit information, receive commands from Earth and measure velocity and distance. UHF links are used to relay information from the lander to the orbiter. Finally, as a special technique for science use, there is an X-band link from the orbiter to Earth.

The S-band systems using broad and narrow beam antennas, one used as both the orbiter and lander. The narrow-beam, high-data-rate antennas must be carefully oriented toward Earth. To accomplish this, the antennas are steerable. Due to the planet's rotation, the antenna on the lander must be moved continuously during each transmission period. The fixed broad-beam, low-data-rate antennas are used to receive signals from Earth.

The lander-to-orbiter communication link is an ultra-high-frequency (UHF) system that is used for rapid, high-volume transmission. The orbiter records these data and then plays them back to Earth over its S-band system. The X-band system on the orbiter is used for radio science only. The orbiter/lander UHF system begins operating when the lander separates from the orbiter, and continues operating through the descent and landing. The relay link will be activated again each day when the orbiter passes over the lander.

#### MANAGEMENT RESPONSIBILITIES

Viking management is under the overall direction of the Office of Planetary Programs, Office of Space Science, NASA Headquarters. Langley Research Center, Hampton, Va., exercises overall project management and is responsible for the lander portion of Viking. The Jet Propulsion Laboratory, Pasadena, Calif., is responsible for the orbiter and the Deep Space Network. Lewis Research Center, Cleveland, Ohio, is responsible for the Titan/Centaur launch vehicle and integration of the spacecraft to the launch vehicle. Kennedy Space Center is in charge of launch operations.

Major contractor is the Martin Marietta Corporation, Denver, which is responsible for the lander and systems integration and builds the Titan III booster. General Dynamics/Convair, San Diego, Calif., builds the upper stage Centaur.

### VIKING SCIENCE TEAMS

Teams of scientists were selected by the National Aeronautics and Space Administration to direct the Viking scientific investigations. These scientists interact with project engineers who are responsible for hardware design, test and fabrication of flight hardware.

Scientists and engineers working together determine details of the investigations and instruments; the compromises that must be made because of weight, power, or data constraints; and the ultimate flexibility of experiments.

Each science team has a leader who is also a member of the Science Steering Group that develops the scientific policies and contributes to the overall coordination of Viking science requirements.

#### Science Steering Group

Dr. Gerald A. Soffen, Chairman, Langley Research Center,  
Hampton, Va.  
Dr. Richard S. Young, Vice Chairman, NASA Headquarters,  
Washington, D.C.  
Dr. A. Thomas Young, Langley Research Center  
Dr. Conway W. Snyder, Jet Propulsion Laboratory, Pasadena, Calif.  
Dr. Paul V. Fennessey, Martin Marietta Aerospace, Denver, Colo.

#### Orbiter Imaging

Dr. Michael H. Carr, U.S. Geological Survey, Menlo Park, Calif.  
William A. Baum, Lowell Observatory, Flagstaff, Ariz.  
Geoffrey A. Briggs, Bellcomm Inc., Washington, D.C.  
Dr. Harold Masursky, U.S. Geological Survey, Flagstaff, Ariz.  
James A. Cutts, Jet Propulsion Laboratory  
Donald U. Wise, University of Massachusetts, Amherst, Mass.

#### Orbiter Water Vapor Mapping

Dr. Crofton B. Farmer, Jet Propulsion Laboratory  
Daniel D. La Porte, Jet Propulsion Laboratory

#### Orbiter Thermal Mapping

Prof. Hugh H. Kieffer, University of California, Los Angeles, Calif

Orbiter Thermal Mapping (con't.)

Stillman Chase, Santa Barbara Research Corp., Goleta, Calif.  
Ellis D. Miner, Jet Propulsion Laboratory

Lander Imaging

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Alan B. Binder, ITT Research Institute, Tucson, Ariz.  
Elliot C. Levinthal, Stanford University  
Dr. Carl Sagan, Cornell University, Ithaca, N.Y.  
Prof. Sidney Liebes, Stanford University

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Prof. Alexander Rich, Massachusetts Institute of Technology,  
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Vance I. Oyama, Ames Research Center  
Dr. Joshua Lederberg, Stanford University

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Leslie E. Orgel, Salk Institute, San Diego, Calif.  
Tobias Owen, State University of New York, Stony Brook  
Prof. Alfred O.C. Nier, University of Minnesota, Minneapolis, Minn.  
DuWayne M. Anderson, U.S. Army, Cold Regions Research Engineering  
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Robert M. Henry, Langley Research Center  
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Entry

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Prof. Frank Press, Massachusetts Institute of Technology  
Gary Latham, Columbia University, N.Y.  
Prof. Robert A. Kovach, Stanford University  
Prof. M. Nafi Toksz, Massachusetts Institute of Technology  
Prof. George Sutton, University of Hawaii, Honolulu, Hawaii

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Prof. Ronald F. Scott, California Institute of Technology  
Robert E. Hutton, TRW Applied Mechanics Laboratory,  
Redondo Beach, Calif.

Magnetic Properties

Prof. Robert B. Hargraves, Princeton University

Radio

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Dr. Mario D. Grossi, Raytheon Co.  
Prof. Irwin I. Shapiro, Massachusetts Institute of Technology  
Joseph Brenkle, Jet Propulsion Laboratory  
Dan L. Cain, Jet Propulsion Laboratory  
Dr. Gunnar Fjeldbo, Jet Propulsion Laboratory  
Prof. G. Leonard Tyler, Stanford University  
Robert H. Tolson, Langley Research Center

Science Team Leaders or Principal Investigators are  
names first under each group.

VIKING QUESTIONS AND ANSWERS

1. Why go to Mars?

There are many reasons, including scientific, philosophical, technical and national prestige considerations. However, the main purpose is to characterize the planet in as much detail as possible, including the possibility of resolving the question of life on Mars.

2. Why should we know more about other planets?

By comparing other planets with Earth we will be able to better understand the rapid changes here and possible forecast future changes which are now only poorly or not at all understood.

For example, knowledge of other planets' atmospheres should help us better understand our own pollution-threatened atmosphere. Dust storms on Mars supply data on future effects of smoke and particulate pollution in Earth's atmosphere. And study of storms on Mars, whose weather-making mechanism is relatively simple because of that planet's lack of oceans, can contribute to an understanding of Earth's weather, and thus to weather prediction and possibly future weather control.

3. What difference would it make if life were to be discovered on Mars?

Man would have more tools for understanding the origin and nature of life and would be that much closer to understanding his own place and role in the universe.

4. What is Viking?

Viking is a spacecraft consisting of an orbiter and a lander, weighing 3,400 kg (7,500 lbs.), measuring 9.8 m (32 ft.) in width and 4.9 m (16 ft.) in height. The spacecraft will be launched from Cape Kennedy, Fla., aboard a Titan III/Centaur rocket.

5. How big are the orbiters and landers separately?

The orbiter measures 9.8 m (32 ft.) across and 3.3 m (10.8 ft.) top to bottom. It weighs 2,360 kg (5,200 lbs.). The lander, which rests on three legs, measures 2.7 m (9 ft.) across and 2.1 m (7 ft.) top to bottom. It weighs 1,050 kg (2,300 lbs.).

6. When will Viking be launched?

The two Viking spacecraft will be launched separately during a 30-day period, but at least 10 days apart, between mid-August and mid-September in 1975.

7. How far will they travel?

They will travel some 700 million km (440 million mi.) through space on nearly a year's journey to arrive when the planet is about 320 million km (206 million mi.) from Earth on the other side of the Sun.

8. How much will the Viking mission cost?

Between \$920 and \$950 million, not including the launch vehicle. The Titan/Centaurs cost \$66 million.

9. What will Viking do when it gets to Mars?

The orbiter spacecraft will go into orbit and will remain in orbit while the lander will separate and land on the surface anytime within 50 days of arrival, via parachute and retro-rocket. Together they will conduct scientific studies of the Martian atmosphere and surface.

10. What will be the orbits of the orbiters?

The orbit insertion retro-rockets will be fired for nearly an hour to place each Viking into a highly elliptical orbit of 1,500 km (930 mi.) by 33,000 km (20,500 mi.).

11. What instruments will the orbiter carry?

Each orbiter will carry about 65 kg (144 lbs.) of instruments consisting of two high-resolution television cameras, an infrared spectrometer and an infrared radiometer.

12. How long will the orbiter remain in orbit?

The design lifetime is 140 days, but it may operate for as long as two years. Sometime after 50 years, the orbiter will be dragged into the atmosphere of Mars by gravity and burn up or impact the surface.

13. What will the landers carry?

The landed instruments, weighing about 60 kg (133 lbs.), consist of a gas chromatograph/mass spectrometer; biology instrument; two cameras (stereo and color capability); pressure, temperature and wind sensors; three-axis seismometer; bar magnets; a soil sampler; X-ray fluorescence spectrometer; upper atmosphere mass spectrometer and retarding potential analyzer. The soil sampler is not usually called an instrument and its weight is not included in the 18 kg.

14. What would be a likely place for the lander to land?

A candidate landing area would be relatively low, warm, wet, safe, and interesting. Previous Mariner/Mars mission results have been used to help select potential landing sites. In addition, the Viking orbiter will be used for final checkout of a candidate site. The tentative site for the first landing is a valley near the mouth of the 20,000-foot-deep Martian Grand Canyon, known as Chryse (19.5 degrees N, 34 degrees W). The tentative landing site for the second Viking is Cydonia, in the Mare Acidalium region (44.3 degrees N, 10 degrees W).

15. How long will the lander operate?

The primary mission is 60 days. The design lifetime is 90 days, but it may continue to transmit information for more than one year. Certain instruments will not be operable beyond the planned 60-day mission.

16. How do we know we won't be detecting Earth life instead of Martian life?

Because the lander capsules will be heat-sterilized to comply with international planetary quarantine requirements.

17. Where will Viking get power to operate instrumentation?

Solar cells and batteries, recharged by the solar cells, will provide power for both the orbiter and lander while in flight. The orbiter will furnish electrical power to the lander until it is separated for landing. The lander also has a set of rechargeable batteries which will be charged during surface operations by two radioisotope thermo-electric generators (RTGs). The RTGs convert heat produced by a nuclear source into electricity and thus make the landers independent of solar energy.

18. How do we communicate at such vast distances?

Via NASA's Deep Space Network composed of six stations having 26-m (85-ft.) antennas and three other stations with 64-m (210 ft.) antennas. Digital data will be transmitted to Earth to be reproduced into pictures and in tabular form. It will take at least 20 minutes to send a message one way.

19. How many scientists will participate in the mission?

There will be 66 scientists from the United States and other nations participating in the initial examination of data from Viking. We anticipate that many other scientists will participate in later analysis of the data.

20. What have we learned from the previous Mariner flights to Mars that will enable us to have a better chance of success for Viking?

The previous Mariner flights have contributed both engineering and scientific data that improve our chances of success with Viking. On the engineering side we now know considerably more than could be learned from ground observation about the atmosphere, topography and surface characteristics of the planet to aid in trajectory planning and designing the structural features of the lander for safe entry and landing.

Scientifically we know that Mars is a more dynamic body than was previously supposed, with geologically-recent volcanic activity and with occasional violent dust storms. The knowledge of the location of comparatively recent tectonic activity and of apparent surface differentiations, together with the engineering data, will aid in the selection of landing sites, as well as in the planning for the scientific observations.

21. How will the dust storms we saw on Mars with Mariner 9 affect Viking?

The dust storms we saw via Mariner 9 were the longest lasting storms ever observed on the planet. We do not expect such storms to occur during the Viking mission, especially over the entire planet as the 1971-72 storm. However, should storms occur, Viking has a capability of orbiting the planet for almost two months before detaching the lander and then selecting the clearest looking site.

22. Previous Mars journeys took only about six months. Why is the Viking trip so long?

Launch opportunities to Mars with reasonable launch energies and encounter velocities occur at regular intervals of 25.6 months. Some of the opportunities are much more favorable than others. These differences are due to the Mars orbit inclination, eccentricities of the planet orbits, and the locations of the orbit axes. Characteristics of the opportunities tend to repeat in about 15-year cycles.

At most launch opportunities there are two general types of minimum-energy trajectories. Type I trajectories involve trips of less than 180 degrees around the sun and feature short transit times. Type II trajectories require trips of more than 180 degrees around the sun thus requiring longer transit times but also slightly less launch energy.

Viking will utilize Type II trajectories in 1975 with trip times of 10 to 12 months. In contrast, 1971 was a very favorable launch opportunity, so Mariner 9 used a Type I trajectory with a trip time of less than six months.

23. Why was this long-trajectory launch period chosen?

Viking was originally scheduled for launch in 1973, at which time it would have utilized a Type I trajectory with a short trip time. Budget considerations required the launch to be postponed to 1975. Compared to either 1971 or 1973, 1975 is not a favorable launch opportunity in terms of launch-energy requirements and encounter velocities. Therefore, in order for Viking to use the same launch vehicle and spacecraft design planned for 1973, it is necessary for Viking in 1975 to employ a Type II trajectory and travel a heliocentric angle over 180 degrees. The disadvantages are a long trip time and a much greater Mars to Earth distance for communications.

24. Will we try to land on the Fourth of July 1976?

That depends on the date Viking arrives at Mars and the conditions on the planet, whether extensive tracking or continued orbiting to search for a suitable landing site is necessary, the conditions of the orbiter and lander, and other possibilities. If conditions are right, we would be able to land on the 200th anniversary of our Nation's independence.

25. Have we coordinated with the USSR to prevent a redundant mission?

We are presently exchanging scientific data on the findings of Mariner 9 and Mars 4, 5, 6, and 7. The USSR has good access to our plans for Viking '75.

26. Who has endorsed this mission?

The Space Science Board of the National Academy of Sciences and the President, as well as the Congress.